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Mortar Making Qualities
Of Illinois Sands

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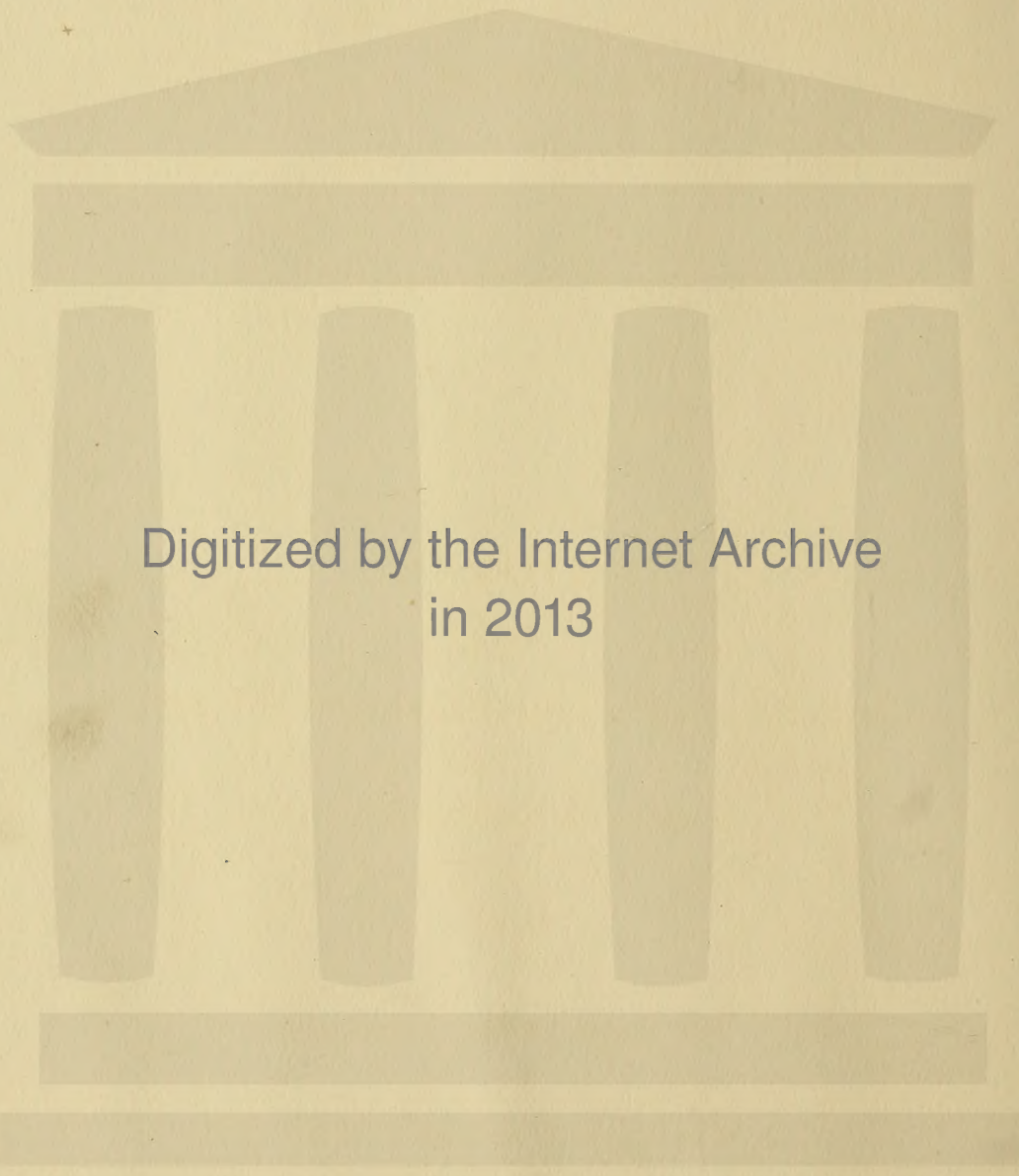
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**MORTAR MAKING QUALITIES
OF ILLINOIS SANDS**

BY

EDWIN BERT ADAMS

THESIS

FOR THE

DEGREE OF BACHELOR OF SCIENCE

IN

CIVIL ENGINEERING

COLLEGE OF ENGINEERING

UNIVERSITY OF ILLINOIS

PRESENTED, JUNE, 1908.

1908
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June 1, 1908

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

EDWIN BERT ADAMS

ENTITLED MORTAR-MAKING QUALITIES OF ILLINOIS SANDS

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Bachelor of Science in Civil Engineering

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UNIVERSITY OF ILLINOIS

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Dec 18, 1944

Mortar Making Qualities of Illinois Sands.

Concrete is an artificial stone made of an aggregate and mortar. The aggregate usually consists of gravel or broken stone, while the mortar usually consists of cement, sand and water. Ever since the discovery of the process of manufacturing Portland cement, the demand for concrete has increased with unlimited bounds, due to its strength, cheapness and ease of handling, until it is one of the most important, if not the most important building material of the twentieth century.

At first, cement manufacturers spent a great deal of time and money to increase the qualities of the cement so that the artificial stone might be more reliable, and this met with the approval of the cement users. To-day Portland cement has nearly reached a climax in the high qualities of a cement, and it is quite necessary to increase the qualities of some other ingredient if the strength of concrete is to increase.

A number of years ago engineers began

to investigate the qualities of the aggregate and the sand, in their endeavor to increase the strength of concrete. Experiments were performed on the aggregate and the desirable and undesirable qualities were satisfactorily determined. In like manner, experiments were performed on the sand and it was found that some sands were three or four times as strong as other sands, when mixed with the same proportions of cement and water. This is a question far more vital now than the cement question, and the successful engineer must know just what kind of sand gives the greatest strength, that he may use to advantage the sands available.

A number of years ago the University of Illinois took up the matter of investigating the qualities of different sands to determine their affects upon the strength of mortar. Last year, 1907, Mr. McManis wrote a thesis upon "Relative Value of Different Sands for Making Mortar", in which he treated Illinois sands. It was decided to continue this work under the title of "Mortar Making Qualities of Illinois Sands", since this is

a question of great importance to Illinois Engineers. Letters were sent to different cities of Illinois asking for a representative sample of the building sand used in their locality. Fourteen cities responded with a total of twenty sands. Below, is a list of the cities that contributed samples, the sample number of the sand, the place where the sand was obtained and the kind of sand.

| Sample Number | City from which sand was Received | Place where sand was obtained | Kind of sand. |
|---------------|-----------------------------------|---|---------------------|
| 1 | Chicago | Chicago (Knickerbocker Ice Co.) | Torpedo |
| 2 | Chicago | Chicago (Zander-Reum Co.) | Bank |
| 3 | Chicago | Chicago (Knickerbocker Ice Co.) | Bank |
| 4 | Chicago | Joliet | Limestone scr'ngs |
| 5 | Elgin | Elgin (Hammond Pit) | Bank (washed.) |
| 6 | Elgin | Elgin (Stimpson Pit) | Bank (screened) |
| 7 | Bloomington | Bloomington | Bank |
| 8 | Rockford | Rockford (Sewer Trench 7 th Ave 10 th St) | Bank |
| 9 | Springfield | Lincoln | Bank |
| 10 | Springfield | Alton | River |
| 11 | Springfield | Alton | River |
| 12 | Champaign | Covington Ind. | Bank |
| 13 | Galesburg | Gladstone | Bank |
| 14 | Decatur | Decatur | Bank (screened) |
| 15 | Freeport | Freeport | Bank |
| 16 | Freeport | Freeport | Sandstone (scr'ngs) |
| 17 | Aurora | Aurora (Lake Pit) | Bank |
| 18 | Joliet | Joliet (Fuller Pit) | Bank |
| 19 | Moline | Moline | River |
| 20 | Urbana | Urbana | Bank |

It is to be noted that some of the cities import their sands a long distance, which goes to show that sand from neighboring pits are of poor quality.

Object

The object of this thesis is to determine the mortar making qualities of Illinois sands. For this purpose the following tests were made viz:— Fineness, Specific Gravity, Voids and Tensile Strength

Preliminary.

The twenty samples of sand were stored in the cement laboratory for about three months, and as the room was kept at about 68° Fahrenheit, the sands were thoroughly dried before testing. Each sample of sand was then screened to pass the one quarter inch sieve, as pebbles larger than one quarter inch are usually classed as gravel and not sand.

Fineness

In determining the fineness of the sand "The Perse Testing Sieve Agitator," was used, which is the standard sand and cement sifting machine manufactured by the Howard and Morse Company of Brooklyn, New York. The machine was driven by

an electric motor at one hundred revolutions per minute, and gives a combined circular and vertical motion, with a drop of one half inch, twice during each revolution, which coincides very closely with hand shaking. The sieves used on this machine were eight inches in diameter, two inches in depth and of the following meshes, #8, #16, #20, #30, #40, #60, #74, #100, and pan.

One thousand grams of the sand was carefully weighed and placed in the top sieve of the Sifting Machine and agitated for thirty minutes. At the end of this time the sand retained on each of the sieves was taken out and carefully weighed. From this data the percent retained on each sieve and the percent passing each sieve was computed. The following table on page 6 give the results of the fineness test.

TABLE I

RESULT OF FINENESS TEST.

| Sample No. | Percent of sand retained on Sieves No. | | | | | | | | | | Total. |
|------------|--|-------|-------|------|-------|-------|-------|-------|-------|------|--------|
| | 4 | 8 | 16 | 20 | 30 | 40 | 60 | 74 | 100 | Pan | |
| 1 | 0.00 | 0.00 | 0.12 | 0.15 | 0.58 | 2.80 | 26.83 | 20.91 | 44.41 | 4.20 | 100.00 |
| 2 | 0.00 | 0.90 | 4.41 | 0.93 | 6.27 | 10.21 | 51.40 | 5.87 | 17.52 | 2.49 | 100.00 |
| 3 | 0.00 | 10.85 | 9.39 | 1.41 | 9.32 | 19.90 | 33.27 | 6.01 | 7.40 | 2.45 | 100.00 |
| 4 | 0.00 | 47.71 | 31.10 | 1.25 | 4.79 | 0.26 | 4.20 | 1.41 | 1.22 | 8.06 | 100.00 |
| 5 | 0.00 | 16.07 | 29.17 | 3.37 | 15.39 | 15.58 | 13.64 | 2.53 | 2.27 | 1.98 | 100.00 |
| 6 | 0.00 | 2.80 | 31.86 | 5.47 | 21.02 | 15.72 | 14.74 | 3.93 | 3.22 | 1.24 | 100.00 |
| 7 | 0.00 | 10.71 | 23.22 | 3.35 | 10.80 | 11.65 | 18.61 | 5.24 | 8.01 | 8.41 | 100.00 |
| 8 | 0.00 | 1.96 | 29.96 | 8.30 | 25.78 | 9.23 | 14.46 | 5.41 | 3.78 | 1.12 | 100.00 |
| 9 | 0.00 | 4.74 | 29.82 | 4.16 | 15.44 | 19.78 | 20.40 | 2.54 | 1.74 | 1.38 | 100.00 |
| 10 | 0.00 | 1.79 | 7.89 | 2.53 | 17.55 | 24.60 | 35.18 | 5.28 | 3.99 | 1.19 | 100.00 |
| 11 | 0.00 | 3.01 | 16.94 | 3.84 | 22.44 | 23.63 | 21.24 | 3.63 | 3.09 | 2.18 | 100.00 |
| 12 | 0.00 | 6.58 | 40.43 | 5.55 | 16.48 | 11.95 | 12.42 | 1.99 | 2.18 | 2.42 | 100.00 |
| 13 | 0.00 | 0.22 | 1.85 | 0.92 | 8.18 | 25.04 | 50.88 | 6.07 | 5.74 | 1.10 | 100.00 |
| 14 | 0.00 | 25.99 | 37.38 | 2.73 | 9.37 | 11.58 | 9.15 | 1.53 | 1.12 | 1.15 | 100.00 |
| 15 | 0.00 | 1.29 | 17.68 | 3.64 | 15.34 | 18.98 | 23.67 | 6.36 | 7.35 | 5.69 | 100.00 |
| 16 | 0.00 | 1.72 | 11.86 | 3.46 | 19.78 | 32.29 | 26.71 | 2.76 | 1.26 | 0.16 | 100.00 |
| 17 | 0.00 | 2.17 | 36.56 | 5.57 | 20.84 | 22.82 | 10.85 | 0.51 | 0.22 | 0.46 | 100.00 |
| 18 | 0.00 | 0.50 | 5.12 | 3.29 | 39.99 | 35.30 | 10.64 | 1.02 | 0.76 | 3.38 | 100.00 |
| 19 | 0.00 | 2.30 | 11.92 | 3.31 | 20.89 | 35.58 | 22.95 | 2.04 | 0.85 | 0.16 | 100.00 |
| 20 | 0.00 | 27.60 | 40.81 | 4.93 | 7.63 | 2.99 | 9.23 | 1.26 | 1.06 | 4.49 | 100.00 |

Specific Gravity

"Le Chateliers," apparatus was used in determining the specific gravity of the sand. It consists of a flask having a capacity of 120 cubic centimeters, and a neck 9 millimeters in diameter, graduated into tenths of cubic centimeters to 100 cubic centimeters. The flask was filled with water at about 58° Fahrenheit. up to the zero mark, and the 100 grams of dried sand (to be tested) was put into the flask by means of a glass funnel. Care being taken that the sand did not clog up the neck of the apparatus. The reading in cubic centimeters was then taken which gave the volume of water displaced by 100 grams of sand. The specific gravity was determined by the following equation

$$\text{Specific Gravity} = \frac{\text{Weight of Sand}}{\text{Displaced Volume}}$$

The results of these tests are recorded on pages 8 and 17 to 37

Note

As a result of observation, it was found that 100 grams of most sands expand about one and a half cubic centimeters in the first twenty minutes they are immersed in

water, hence the readings for specific gravity were taken immediately after running in the sand. Taylor and Thompson, page 176, says the reason for this increased volume is not due to the swelling of the sand but that a film of water coats each particle of sand and separates it by surface tension from the grains surrounding it. The fine sand has a larger number of grains and consequently more surface area and hence increase more in bulk than coarse sand with the addition of water

TABLE.2

RESULT OF SPECIFIC GRAVITY TEST

| Sample No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|-----------------------------|------|------|------|------|------|------|------|------|------|------|
| Number grams sand used | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| No. Cu. Cm. Water displaced | 38.1 | 38.5 | 37.3 | 36.0 | 38.1 | 37.1 | 37.3 | 37.4 | 37.6 | 37.9 |
| Specific Gravity | 2.62 | 2.60 | 2.68 | 2.78 | 2.62 | 2.69 | 2.68 | 2.68 | 2.63 | 2.64 |

| Sample No. | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|-----------------------------|------|------|------|------|------|------|------|------|------|------|
| Number grams sand used | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| No. Cu. Cm. Water displaced | 38.5 | 37.0 | 37.4 | 38.1 | 37.3 | 35.8 | 37.4 | 38.4 | 38.5 | 37.4 |
| Specific Gravity | 2.60 | 2.70 | 2.67 | 2.62 | 2.68 | 2.79 | 2.67 | 2.61 | 2.60 | 2.67 |

Voids

In determining the voids in sand the following method was used. Five hundred cubic centimeters of dry sand was put into a graduated glass beaker and weighed. The weight of the beaker subtracted from the above weight gave the weight of the five hundred cubic centimeters of dry sand. With this data the volume of one hundred grams of sand was calculated. The specific gravity test gives the volume of water displaced by one hundred grams of sand, and this difference between the volume of sand and the volume of water displaced gives the volume of voids in the sand, from which the percentage of voids was readily calculated. The results of these tests are recorded on page 10 and 17 to 37.

TABLE.3

RESULT OF VOID TEST

| Sample No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|--|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Weight(qms.)500 Cu.Cm. sand | 754.7 | 799.7 | 872.4 | 707.1 | 869.0 | 853.0 | 819.3 | 842.6 | 851.0 | 834.3 |
| Volume (Cu.Cm.) of 100 qms. sand | 66.2 | 62.5 | 57.2 | 63.5 | 57.5 | 58.6 | 61.1 | 59.3 | 58.7 | 59.9 |
| Volume water displd by 100 qms sand | 38.1 | 38.5 | 37.3 | 36.0 | 38.1 | 36.7 | 37.3 | 37.4 | 37.6 | 37.9 |
| Voids in Cu. Cm. | 28.1 | 24.0 | 19.9 | 27.5 | 19.4 | 21.9 | 23.8 | 21.9 | 21.1 | 22.0 |
| Percent of Voids | 42.4 | 38.4 | 34.8 | 43.3 | 33.8 | 37.5 | 38.9 | 36.9 | 35.9 | 36.7 |

| Sample No. | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Weight(qms.) 500 Cu. Cm. sand | 845.2 | 854.3 | 796.7 | 832.7 | 814.3 | 791.2 | 833.4 | 714.8 | 846.0 | 796.7 |
| Volume (Cu.Cm.) of 100 qms. sand | 59.2 | 58.5 | 62.8 | 60.0 | 61.4 | 63.2 | 60.0 | 69.9 | 59.1 | 62.7 |
| Volume water displd by 100 qms. sand | 38.5 | 37.0 | 37.4 | 38.1 | 37.3 | 35.8 | 37.4 | 38.4 | 38.5 | 37.4 |
| Voids in Cu. Cm. | 20.7 | 21.5 | 25.4 | 21.9 | 24.1 | 27.4 | 22.6 | 31.5 | 20.6 | 25.3 |
| Percent of Voids | 34.9 | 36.7 | 40.4 | 36.5 | 39.2 | 43.3 | 37.7 | 45.0 | 34.8 | 40.3 |

Tensile Strength.

Cement.

The Chicago A-A, cement was used throughout this thesis

Proportions

The proportions used in making briquettes were one part cement, by weight, to three parts sand, by weight, and ten percent of water, by weight.

Mixing.

One thousand grams of cement and three thousand grams of sand were carefully mixed on a slate table, three four hundred cubic centimeters of water was added, and thoroughly troweled. With this material twenty seven briquettes were made. These quantities were used because they made a mixture sufficiently large for the desired number of briquettes, and the mixture could readily be molded before it began to set.

Molding.

The method used in molding briquettes was that recommended by the American Society of Civil Engineers. The standard bronze molds were used, and the mortar

was pressed firmly into the molds with the fingers, and smoothed off with the trowel, so that a moderate pressure was exerted on the material. The mold was turned over and the trowelling repeated.

Storing

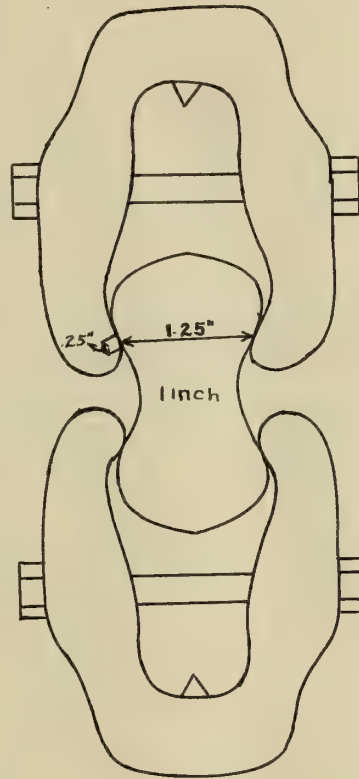
A damp cloth was spread over the molds, with a tin pan over the cloth to prevent the briquettes from drying out. At the end of twenty four hours the briquettes were taken from the molds and stored in water maintained at about 70° Fahrenheit until time of testing.

Testing

In determining the tensile strength of the briquettes the "Richle Testing Machine," was used, which is a direct reading automatic shot machine.

The briquettes were tested at intervals of 7 days, 28 days, and 90 days. Care was taken that the briquettes were tested soon after taking them from the water, and that each briquette was carefully centered in the testing machine. The load was applied at the rate of six hundred pounds per minute. The results

of these tests are found in table 4. pages
17 to 37.



Form of Clip.

Conclusions

In the past, nearly all specifications have called for clean, sharp sand. Experiments have shown that the sand should be clean and free from earthy material, but the sharpness of the grains is subordinate, and of less importance than the size of the grains. By an examination of the fineness and tensile tests it is noted that the coarser sands give the stronger mortar, because the coarser sands have less surface to be covered and hence requires less cement. The finer sands have more grains in a unit measure than the coarser sands, and hence a greater number of points of contact, and a greater chance of the water separating the grains by surface tension. Therefore the size of sand grains should also be included in the specifications.

By an examination of the fineness and void tests, it is noted that the proportions of voids depend upon the gradation of sizes of sand grains, and not upon the size of size of sand grains, as one might suppose. The sand having a minimum amount of voids is a sand of a variation of sizes

of grains so that the smaller grains fit into the interstices between the larger grains, the proportion being just sufficient to fill the voids. The smaller the percentage of voids the denser and stronger the material.

The specific gravity of a sand does not directly tell anything in regard to the quality of the sand, but indirectly it gives some indication of the strength or make up of the sand grains themselves. The specific gravity test was therefore made only for use in determining the percent of voids in the sand.

Since there was but one sample of sandstone screenings and one sample of limestone screenings there can not be any definite conclusions drawn from these tests, although the indications are that the limestone screenings are stronger than natural sands, and the sandstone screenings weaker than the natural sands.

It may be more economical to bring good sand from a distance than to use sand from a neighboring bank, depending on the work for which the sand is required. Sample Number 19, "Moline Sand," gives a

stronger tensile strength for twenty eight days than for ninety days, which goes to show that this is a poor sand, and is probably due to some chemical reaction between the sand and cement which breaks down the mortar to some extent.

In conclusion, "Illinois Sands", on the average are suitable sands for building mortars, although there are a few samples such as Sample Number 18 (Joliet sand) which do not make a very strong reliable mortar.

Description of Tables.

Table 1, Page 6, shows the results of the Fineness Test.

Table 2, Page 8, shows the results of the Specific Gravity Test.

Table 3, Page 10, shows the results of the Void Test.

Table 4, Pages 17 to 37, shows the Tensile Strength, Fineness, Voids and Specific Gravity of each sample of sand.

Table 5, Page 38, shows the ranking of the sands in regard to:- first, Tensile Strength; second, Voids.

TABLE.4

TESTS OF
TENSILE STRENGTH
FINENESS
VOIDS
SPECIFIC GRAVITY

PAGES 17-37

SAMPLE NO.1.

Received from Chicago Obtained at Chicago Kn.I.Co.
TENSILE STRENGTH

| NO | 7Day Test | 28Day Test | 90Day Test |
|---------|-----------|------------|------------|
| 1 | 116 | 200 | 238 |
| 2 | 144 | 190 | 249 |
| 3 | 144 | 160 | 235 |
| 4 | 118 | 170 | 239 |
| 5 | 145 | 210 | 259 |
| 6 | 157 | 187 | 242 |
| 7 | 146 | 182 | 253 |
| 8 | 143 | 190 | 248 |
| 9 | 135 | 181 | 248 |
| Average | 139 | 186 | 246 |

FINENESS

| Standard Mesh | Quantity Retained | Quantity Passing | Percent Retained | Percent Passing |
|---------------|-------------------|------------------|------------------|-----------------|
| 4 | 0.0 | 1000.0 | 0.00 | 100.00 |
| 8 | 0.0 | 1000.0 | 0.00 | 100.00 |
| 16 | 1.2 | 998.8 | .12 | 99.88 |
| 20 | 1.5 | 997.3 | .15 | 99.73 |
| 30 | 5.8 | 991.5 | .58 | 99.15 |
| 40 | 28.0 | 963.5 | 2.80 | 96.35 |
| 60 | 268.3 | 695.2 | 26.83 | 69.52 |
| 74 | 209.1 | 486.1 | 20.91 | 48.61 |
| 100 | 444.1 | 42.0 | 44.41 | 4.20 |
| Pan | 42.0 | 0.0 | 4.20 | 0.00 |
| Total | 1000.0 | 1000.0 | 100.00 | 100.00 |

VOIDS

| | |
|---|-------|
| Weight (gms) 500 Cu. Cm. Sand. | 754.7 |
| Volume (Cu. Cm) 100 gms Sand | 66.2 |
| Volume (Cu. Cm.) water displaced by 100gms sand | 38.1 |
| Voids in Cu. Cm. | 28.1 |
| Percentage of Voids | 42.4 |

SPECIFIC GRAVITY

| | |
|---|------|
| No. gms sand used | 100. |
| Volume (Cu. Cm) of water displaced by 100 gms sand. | 38.1 |
| Specific Gravity | 2.62 |



SAMPLE NO 2.

Received from Chicago Obtained at Chicago. Z.R. Co.

TENSILE STRENGTH

| NO. | 7 Day Test | 28 Day Test | 90 Day Test. |
|---------|------------|-------------|--------------|
| 1 | 184 | 274 | 375 |
| 2 | 172 | 272 | 350 |
| 3 | 199 | 312 | 376 |
| 4 | 161 | 255 | 364 |
| 5 | 140 | 262 | 399 |
| 6 | 140 | 230 | 374 |
| 7 | 132 | 250 | 372 |
| 8 | 158 | 298 | 375 |
| 9 | 178 | 271 | 385 |
| Average | 170 | 269 | 375 |

FINENESS

| Standard Mesh | Quantity Retained | Quantity Passing | Percent Retained | Percent Passing. |
|---------------|-------------------|------------------|------------------|------------------|
| 4 | 0.0 | 1000.0 | .00 | 100.00 |
| 8 | 9.0 | 991.0 | .90 | 99.10 |
| 16 | 44.1 | 946.9 | 4.41 | 94.69 |
| 20 | 9.3 | 937.6 | .93 | 93.76 |
| 30 | 62.7 | 874.9 | 6.27 | 87.49 |
| 40 | 102.1 | 772.8 | 10.21 | 77.28 |
| 60 | 514.0 | 258.8 | 51.40 | 25.88 |
| 74 | 58.7 | 200.1 | 5.87 | 20.01 |
| 100 | 175.2 | 24.9 | 17.52 | 2.49 |
| Pan. | 24.9 | 0.0 | 2.49 | 0.00 |
| Total. | 1000.0 | 1000.0 | 100.00 | 100.00 |

VOIDS

| | |
|--|-------|
| Weight (qms) 500 Cu. Cm. Sand | 799.7 |
| Volume (Cu. Cm) 100 qms Sand. | 62.5 |
| Volume (Cu. Cm.) water displaced by 100 qms sand | 38.5 |
| Voids in. Cu. Cm. | 24.0 |
| Percentage of Voids | 38.4 |

SPECIFIC GRAVITY

| | |
|---|-------|
| No. qms sand used | 100.0 |
| Volume (Cu. Cm.) of water displaced by 100 qms sand | 38.5 |
| Specific Gravity | 2.60 |

SAMPLE NO3

Received from Chicago Obtained at Chicago. Kn. I. Co.

TENSILE STRENGTH

| No. | 7 Day Test. | 28 Day Test | 90 Day Test. |
|---------|-------------|-------------|--------------|
| 1 | 173 | 280 | 285 |
| 2 | 150 | 238 | 308 |
| 3 | 170 | 273 | 288 |
| 4 | 150 | 286 | 340 |
| 5 | 173 | 270 | 308 |
| 6 | 190 | 268 | 335 |
| 7 | 160 | 265 | 332 |
| 8 | 180 | 245 | 365 |
| 9 | 174 | 254 | 320 |
| Average | 169 | 264 | 320 |

| Standard Mesh | Quantity Retained | Quantity Passing | Percent Retained | Percent. Passing. |
|---------------|-------------------|------------------|------------------|-------------------|
| 4 | 0.00 | 1000.0 | 0.00 | 100.00 |
| 8 | 108.50 | 891.5 | 10.85 | 89.15 |
| 16 | 93.90 | 797.6 | 9.39 | 79.76 |
| 20 | 14.10 | 783.5 | 1.41 | 78.35 |
| 30 | 93.20 | 690.3 | 9.32 | 69.03 |
| 40 | 199.00 | 491.3 | 19.90 | 49.13 |
| 60 | 332.70 | 158.6 | 33.27 | 15.86 |
| 74 | 60.10 | 98.5 | 6.01 | 9.85 |
| 100 | 74.00 | 24.5 | 7.40 | 2.45 |
| Pan | 24.50 | 0.0 | 2.45 | 0.00 |
| Total. | 1000.00 | 1000.0 | 100.00 | 100.00 |

VOIDS

| | |
|---|------|
| Weight (qmsl. 500 Cu. Cm. sand. | 8724 |
| Volume (Cu. Cm.) 100 qms sand. | 57.2 |
| Volume (Cu. Cm) water displaced by 100 qms sand | 37.3 |
| Voids in. Cu. Cm. | 19.9 |
| Percentage of Voids | 34.8 |

SPECIFIC GRAVITY

| | |
|---|-------|
| No qms sand used | 100.0 |
| Volume (Cu. Cm) of water displaced by 100 qms sand. | 37.3 |
| Specific Gravity | 2.68 |

SAMPLE NO4

Received from Chicago Obtained at Joliet

TENSILE STRENGTH

| No. | 7 Day Test | 28 Day Test | 90 Day Test |
|---------|------------|-------------|-------------|
| 1 | 232 | 320 | 470 |
| 2 | 295 | 374 | 465 |
| 3 | 260 | 395 | 585 |
| 4 | 242 | 340 | 440 |
| 5 | 270 | 362 | 437 |
| 6 | 260 | 325 | 522 |
| 7 | 255 | 372 | 530 |
| 8 | 240 | 350 | 395 |
| 9 | 242 | 360 | 435 |
| Average | 255 | 355 | 461 |

FINENESS

| Standard Mesh | Quantity Retained | Quantity Passing | Percent Retained | Percent Passing |
|---------------|-------------------|------------------|------------------|-----------------|
| 4 | 00.0 | 1000.0 | 0.00 | 100.00 |
| 8 | 477.1 | 522.9 | 47.71 | 52.29 |
| 16 | 311.0 | 211.9 | 31.10 | 21.19 |
| 20 | 12.5 | 199.4 | 1.25 | 19.94 |
| 30 | 47.9 | 151.5 | 4.79 | 15.15 |
| 40 | 2.6 | 148.9 | .26 | 14.89 |
| 60 | 42.0 | 106.9 | 4.20 | 10.69 |
| 74 | 14.1 | 92.8 | 1.41 | 9.28 |
| 100 | 12.2 | 80.6 | 1.22 | 8.06 |
| Fin. | 80.6 | 0.0 | 8.06 | 0.00 |
| Total. | 1000.0 | 1000.0 | 100.00 | 100.00 |

VOIDS

| | |
|--|-------|
| Weight(gms) 500 Cu. Cm. sand. | 707.1 |
| Volume(Cu. Cm.) 100. gms. sand. | 63.5 |
| Volume(Cu. Cm.) water displaced by 100gms. sand. | 36.0 |
| Voids in Cu. Cm. | 27.5 |
| Percentage of Voids | 43.3 |

SPECIFIC GRAVITY

| | |
|---|-------|
| No. gms sand. used. | 100.0 |
| Volume(Cu. Cm.) of water displaced by 100 gms. sand | 36.0 |
| Specific Gravity | 2.78 |

SAMPLE NO 5

Received from Elgin Obtained at Elgin. H.P.

TENSILE STRENGTH

| NO | 7 Day Test | 28 Day Test | 90 Day Test |
|---------|------------|-------------|-------------|
| 1 | 290 | 378 | 490 |
| 2 | 310 | 373 | 512 |
| 3 | 255 | 433 | 540 |
| 4 | 355 | 333 | 510 |
| 5 | 285 | 384 | 506 |
| 6 | 298 | 335 | 526 |
| 7 | 296 | 407 | 552 |
| 8 | 306 | 380 | 570 |
| 9 | 300 | 360 | 518 |
| Average | 299 | 377 | 525 |

FINENESS

| Standard Mesh | Quantity Retained | Quantity Passing | Percent Retained | Percent Passing |
|---------------|-------------------|------------------|------------------|-----------------|
| 4 | 0.0 | 1000.0 | 0.00 | 100.00 |
| 8 | 160.7 | 839.3 | 16.07 | 83.93 |
| 16 | 291.7 | 547.6 | 29.17 | 54.76 |
| 20 | 33.7 | 513.9 | 3.37 | 51.39 |
| 30 | 153.9 | 360.0 | 15.39 | 36.00 |
| 40 | 155.8 | 204.2 | 15.58 | 20.42 |
| 60 | 136.4 | 67.8 | 13.64 | 6.78 |
| 74 | 25.3 | 42.5 | 2.53 | 4.25 |
| 100 | 22.7 | 19.8 | 2.27 | 1.98 |
| Pan | 19.8 | 0.0 | 1.98 | 0.00 |
| Total | 1000.0 | 1000.0 | 100.00 | 100.00 |

VOIDS

| | |
|--|-------|
| Weight (gms) 500 Cu. Cm. sand. | 869.0 |
| Volume (Cu. Cm) 100 qms. sand. | 57.5 |
| Volume (Cu. Cm) of water displaced by 100 qms sand | 38.1 |
| Voids in Cu. Cm. | 19.4 |
| Percentage of Voids | 33.8 |

SPECIFIC GRAVITY

| | |
|---|-------|
| No. qms. sand used. | 100.0 |
| Volume (Cu. Cm.) of water displaced by 100 qms sand | 38.1 |
| Specific Gravity | 2.62 |

SAMPLE NO6.

Received from Elgin.

Obtained at Elgin. S. Pit.

TENSILE STRENGTH

| No | 7 Day Test. | 28 Day Test. | 90 Day Test. |
|---------|-------------|--------------|--------------|
| 1 | 285 | 405 | 550 |
| 2 | 315 | 370 | 532 |
| 3 | 295 | 418 | 524 |
| 4 | 305 | 408 | 464 |
| 5 | 280 | 345 | 522 |
| 6 | 300 | 345 | 480 |
| 7 | 295 | 355 | 542 |
| 8 | 290 | 395 | 506 |
| 9 | 299 | 388 | 530 |
| Average | 296 | 381. | 517 |

FINENESS

| Standard Mesh | Quantity Retained | Quantity Passing | Percent Retained | Percent Passing |
|---------------|-------------------|------------------|------------------|-----------------|
| 4 | 0.00 | 1000.0 | 0.00 | 100.00 |
| 8 | 28.0 | 972.0 | 2.80 | 97.20 |
| 16 | 318.6 | 653.4 | 31.86 | 65.34 |
| 20 | 54.7 | 598.7 | 5.47 | 59.87 |
| 30 | 210.2 | 388.5 | 21.02 | 38.85 |
| 40 | 157.2 | 231.3 | 15.72 | 23.13 |
| 60 | 147.4 | 83.9 | 14.74 | 8.39 |
| 74 | 39.3 | 44.6 | 3.93 | 4.46 |
| 100 | 32.2 | 12.4 | 3.22 | 1.24 |
| Pan | 12.4 | 0.0 | 1.24 | 0.00 |
| Total. | 1000.0 | 1000.0 | 1000.0 | 100.00 |

VOIDS

| | |
|--|-------|
| Weight (gms.) 500 Cu. Cm. sand | 853.0 |
| Volume (Cu. Cm.) 100 gms. sand. | 58.6 |
| Volume (Cu. Cm.) of water displaced by 100 gms sand. | 36.7 |
| Voids in Cu. Cm. | 21.9 |
| Percentage of Voids. | 37.5 |

SPECIFIC GRAVITY

| | |
|--|-------|
| No. gms sand used | 100.0 |
| Volume (Cu. Cm.) of water displaced by 100 gms. sand | 37.1 |
| Specific Gravity. | 2.69 |

SAMPLE NO7

Received from Bloomington Obtained at. Bloomington.
TENSILE STRENGTH

| No. | 7 Day Test. | 28 Day Test | 90 Day Test |
|---------|-------------|-------------|-------------|
| 1 | 202 | 188 | 294 |
| 2 | 180 | 265 | 270 |
| 3 | 180 | 205 | 269 |
| 4 | 210 | 262 | 259 |
| 5 | 170 | 270 | 279 |
| 6 | 206 | 210 | 274 |
| 7 | 208 | 270 | 251 |
| 8 | 192 | 215 | 265 |
| 9 | 185 | 239 | 268 |
| Average | 184 | 236 | 269 |

FINENESS

| Standard Mesh | Quantity Retained | Quantity Passing | Percent Retained | Percent Passing. |
|---------------|-------------------|------------------|------------------|------------------|
| 4 | 0.0 | 1000.0 | 0.00 | 100.00 |
| 8 | 107.1 | 892.9 | 10.71 | 89.29 |
| 16 | 232.2 | 660.7 | 23.22 | 66.07 |
| 20 | 33.5 | 627.2 | 3.35 | 62.72 |
| 30 | 108.0 | 519.2 | 10.80 | 51.92 |
| 40 | 116.5 | 402.7 | 11.65 | 40.27 |
| 60 | 186.1 | 216.6 | 18.61 | 21.66 |
| 74 | 52.4 | 164.2 | 5.24 | 16.42 |
| 100 | 80.1 | 84.1 | 8.01 | 8.41 |
| Pan | 84.1 | 0.0 | 8.41 | 0.00 |
| Total. | 1000.0 | 1000.0 | 100.00 | 100.00 |

VOIDS

| | |
|--|-------|
| Weight (gms). 500 (Cu. Cm) Sand. | 819.3 |
| Volume (Cu. Cm.) 100 gms sand. | 61.1 |
| Volume (Cu. Cm.) of water displaced by 100 gms sand | 37.3 |
| Voids in Cu. Cm. | 23.8 |
| Percentage of Voids. | 38.9 |

SPECIFIC GRAVITY

| | |
|--|-------|
| No. gms. sand used | 100.0 |
| Volume (Cu. Cm.) of water displaced by 100gms. sand | 37.3 |
| Specific Gravity. | 2.68 |

SAMPLE NO 8

Received from Rockford. Obtained at Rockford.

TENSILE STRENGTH

| No | 7 Day Test | 28 Day Test | 90 Day Test |
|---------|------------|-------------|-------------|
| 1 | 250 | 255 | 437 |
| 2 | 230 | 250 | 420 |
| 3 | 250 | 300 | 416 |
| 4 | 250 | 280 | 412 |
| 5 | 212 | 250 | 375 |
| 6 | 234 | 260 | 404 |
| 7 | 222 | 260 | 410 |
| 8 | 230 | 275 | 401 |
| 9 | 223 | 264 | 420 |
| Average | 225 | 266 | 411. |

FINENESS.

| Standard Mesh | Quantity Retained | Quantity Passing | Percent Retained | Percent Passing. |
|---------------|-------------------|------------------|------------------|------------------|
| 4 | 0.0 | 1000.0 | 0.00 | 100.00 |
| 8 | 19.6 | 980.4 | 1.96 | 98.04 |
| 16 | 299.6 | 680.8 | 29.96 | 68.08 |
| 20 | 83.0 | 597.8 | 8.30 | 59.78 |
| 30 | 257.8 | 340.0 | 25.78 | 34.00 |
| 40 | 92.3 | 247.7 | 9.23 | 24.77 |
| 60 | 144.6 | 103.1 | 14.46 | 10.31 |
| 74 | 54.1 | 49.0 | 5.41 | 4.90 |
| 100 | 37.8 | 11.2 | 3.78 | 1.12 |
| Pan | 11.2 | 0.0 | 1.12 | 0.00 |
| Total. | 1000.0 | 1000.0 | 100.00 | 100.00 |

VOIDS

SPECIFIC GRAVITY

| | |
|---|-------|
| Weight (gms) 500 Cu. Cm. sand. | 842.6 |
| Volume (Cu. Cm.) 100 gms. sand. | 59.3 |
| Volume (Cu. Cm.) of water displaced by 100 gms. sand. | 37.4 |
| Voids in Cu. Cm. | 21.9 |
| Percentage of Voids. | 36.9 |

| | |
|--|-------|
| No. gms. sand used | 100.0 |
| Volume (Cu. Cm.) of water displaced by 100 gms. sand | 37.4 |
| Specific Gravity | 2.68 |

SAMPLE NO 9.

Received from. Springfield Obtained at Lincoln.

TENSILE STRENGTH

| No. | 7 Day Test | 28 Day Test | 90 Day Test |
|---------|------------|-------------|-------------|
| 1 | 180 | 232 | 318 |
| 2 | 190 | 240 | 375 |
| 3 | 182 | 230 | 350 |
| 4 | 180 | 270 | 342 |
| 5 | 250 | 238 | 352 |
| 6 | 200 | 250 | 340 |
| 7 | 215 | 262 | 350 |
| 8 | 195 | 285 | 342 |
| 9 | 205 | 265 | 345 |
| Average | 200. | 252 | 346 |

FINENESS

| Standard Mesh | Quantity Retained | Quantity Passing | Percent Retained | Percent Passing. |
|---------------|-------------------|------------------|------------------|------------------|
| 4 | 0.0 | 1000.0 | 0.00 | 100.00 |
| 8 | 47.4 | 952.6 | 4.74 | 95.26 |
| 16 | 298.2 | 654.4 | 29.82 | 65.44 |
| 20 | 41.6 | 612.8 | 4.16 | 61.28 |
| 30 | 154.4 | 458.4 | 15.44 | 45.84 |
| 40 | 197.8 | 260.6 | 19.78 | 26.06 |
| 60 | 204.0 | 56.6 | 20.40 | 5.66 |
| 74 | 25.4 | 31.2 | 2.54 | 3.12 |
| 100 | 17.4 | 13.8 | 1.74 | 1.38 |
| Pan | 13.8 | 0.0 | 1.38 | 0.00 |
| Total. | 1000.0 | 1000.0 | 100.00 | 100.00 |

VOIDS

| | |
|---|-------|
| Weight (gms) 500 Cu. Cm. sand. | 851.0 |
| Volume (Cu. Cm.) 100 gms sand. | 58.7 |
| Volume (Cu. Cm.) of water displaced by 100 gms. sand. | 37.6 |
| Voids in Cu. Cm. | 21.1 |
| Percentage of Voids | 35.9 |

SPECIFIC GRAVITY

| | |
|--|-------|
| No. gms. sand used | 100.0 |
| Volume (Cu. Cm.) of water displaced by 100 gms sand. | 37.6 |
| Specific Gravity | 2.63 |

SAMPLE NO 10.

Received from Springfield. Obtained at Alton.

TENSILE STRENGTH

| No. | 7 Day Test | 28 Day Test | 90 Day Test |
|---------|------------|-------------|-------------|
| 1 | 130 | 245 | 276 |
| 2 | 190 | 255 | 271 |
| 3 | 150 | 245 | 284 |
| 4 | 180 | 258 | 242 |
| 5 | 175 | 240 | 285 |
| 6 | 170 | 270 | 289 |
| 7 | 160 | 275 | 271 |
| 8 | 210 | 260 | 272 |
| 9 | 150 | 275 | 258 |
| Average | 168 | 258 | 272 |

FINENESS

| Standard Mesh | Quantity Retained | Quantity Passing | Percent Retained | Percent Passing |
|---------------|-------------------|------------------|------------------|-----------------|
| 4 | 0.0 | 1000.0 | 0.00 | 100.00 |
| 8 | 17.9 | 982.1 | 1.79 | 98.21 |
| 16 | 78.9 | 903.2 | 7.89 | 90.32 |
| 20 | 25.3 | 877.9 | 2.53 | 87.78 |
| 30 | 175.5 | 702.4 | 17.55 | 70.24 |
| 40 | 246.0 | 456.4 | 24.60 | 45.64 |
| 60 | 351.8 | 104.6 | 35.18 | 10.46 |
| 74 | 52.8 | 51.8 | 5.28 | 5.18 |
| 100 | 39.9 | 11.9 | 3.99 | 1.19 |
| Pan. | 11.9 | 0.0 | 1.19 | 0.00 |
| Total. | 1000.0 | 1000.0 | 100.00 | 100.00 |

VOIDS

| | |
|---|-------|
| Weight (gms) 500. Cu. Cm. sand. | 834.3 |
| Volume (Cu. Cm.) 100 gms sand | 59.9 |
| Volume (Cu. Cm.) of water displaced by 100 gms. sand. | 37.9 |
| Voids in Cu. Cm. | 22.0 |
| Percentage of Voids | 36.7 |

SPECIFIC GRAVITY

| | |
|--|-------|
| No. gms sand used | 100.0 |
| Volume (Cu. Cm.) water displaced by 100 gms sand | 37.9 |
| Specific Gravity | 2.64 |

SAMPLE NO 11.

Received from Springfield Obtained at Alton.

TENSILE STRENGTH

| No. | 7 Day Test | 28 Day Test | 90 Day Test |
|---------|------------|-------------|-------------|
| 1 | 208 | 260 | 320 |
| 2 | 184 | 220 | 288 |
| 3 | 190 | 244 | 282 |
| 4 | 195 | 252 | 281 |
| 5 | 200 | 253 | 292 |
| 6 | 200 | 270 | 292 |
| 7 | 196 | 264 | 281 |
| 8 | 195 | 254 | 280 |
| 9 | 190 | 256 | 278 |
| Average | 195 | 253 | 287 |

FINENESS

| Standard Mesh | Quantity Retained | Quantity Passing | Percent Retained | Percent Passing |
|---------------|-------------------|------------------|------------------|-----------------|
| 4 | 0.0 | 1000.0 | 00.00 | 100.00 |
| 8 | 30.1 | 969.9 | 3.01 | 96.99 |
| 16 | 169.4 | 800.5 | 16.94 | 80.05 |
| 20 | 38.4 | 762.1 | 3.84 | 76.21 |
| 30 | 224.4 | 537.7 | 22.44 | 53.77 |
| 40 | 236.3 | 301.4 | 23.63 | 30.14 |
| 60 | 212.4 | 89.0 | 21.24 | 8.90 |
| 74 | 36.3 | 52.7 | 3.63 | 5.27 |
| 100 | 30.9 | 21.8 | 3.09 | 2.18 |
| Pan | 21.8 | 0.0 | 2.18 | 0.00 |
| Total. | 1000.0 | 1000.0 | 100.00 | 100.00 |

VOIDS

SPECIFIC GRAVITY

| | |
|--|-------|
| Weight (gms.) 500 Cu. Cm. sand. | 845.2 |
| Volume (Cu. Cm.) 100. gms. sand. | 59.2 |
| Volume (Cu. Cm.) of water displaced by 100 gms. sand | 38.5 |
| Voids in Cu. Cm. | 20.7 |
| Percentage of Voids | 34.9 |

| | |
|---|-------|
| No. gms. sand used. | 100.0 |
| Volume (Cu. Cm.) of water displaced by 100 gms sand | 38.5 |
| Specific Gravity | 2.60 |

SAMPLE NO 12.

Received from Champaign. Obtained at Covington Ind.

TENSILE STRENGTH

| No. | 7 Day Test | 28 Day Test | 90 Day Test. |
|---------|------------|-------------|--------------|
| 1 | 325 | 475 | 550 |
| 2 | 345 | 460 | 540 |
| 3 | 385 | 385 | 574 |
| 4 | 322 | 420 | 584 |
| 5 | 322 | 422 | 592 |
| 6 | 315 | 462 | 562 |
| 7 | 355 | 470 | 530 |
| 8 | 380 | 482 | 565 |
| 9 | 346 | 451 | 563 |
| Average | 338 | 454 | 562. |

FINENESS

| Standard Mesh | Quantity Retained | Quantity Passing | Percent Retained | Percent Passing |
|---------------|-------------------|------------------|------------------|-----------------|
| 4 | 0.0 | 1000.0 | 0.00 | 100.00 |
| 8 | 65.8 | 934.2 | 6.58 | 93.42 |
| 16 | 404.3 | 529.9 | 40.43 | 52.99 |
| 20 | 55.5 | 474.4 | 5.55 | 47.44 |
| 30 | 164.8 | 309.6 | 16.48 | 30.96 |
| 40 | 119.5 | 190.1 | 11.95 | 19.01 |
| 60 | 124.2 | 65.9 | 12.42 | 6.59 |
| 74 | 19.9 | 46.0 | 1.99 | 4.60 |
| 100 | 21.8 | 24.2 | 2.18 | 2.42 |
| Pan | 24.2 | 0.0 | 2.42 | 0.00 |
| Total. | 1000.0 | 1000.0 | 100.00 | 100.00 |

VOIDS

SPECIFIC GRAVITY

| | |
|--|-------|
| Weight (gms.) 500 Cu. Cm. sand. | 854.3 |
| Volume (Cu. Cm.) 100. gms. sand. | 58.5 |
| Volume (Cu. Cm.) of water displaced by 100 gms. sand | 37.0 |
| Voids in Cu. Cm. | 21.5 |
| Percentage of Voids | 36.7 |

| | |
|--|-------|
| No. gms. sand used. | 100.0 |
| Volume (Cu. Cm.) of water displaced by 100. gms. sand. | 37.0 |
| Specific Gravity | 2.70 |

SAMPLE NO13.

Received from Galesburg Obtained at Gladstone

TENSILE STRENGTH

| No. | 7Day Test. | 28Day Test | 90Day Test |
|---------|------------|------------|------------|
| 1 | 200 | 240 | 240 |
| 2 | 208 | 195 | 275 |
| 3 | 205 | 218 | 273 |
| 4 | 190 | 196 | 278 |
| 5 | 190 | 205 | 250 |
| 6 | 210 | 245 | 282 |
| 7 | 210 | 232 | 281 |
| 8 | 210 | 204 | 284 |
| 9 | 185 | 218 | 274 |
| Average | 201 | 217 | 271 |

FINENESS

| Standard Mesh | Quantity Retained | Quantity Passing | Percent Retained | Percent Passing |
|---------------|-------------------|------------------|------------------|-----------------|
| 4 | 0.0 | 1000.0 | 0.00 | 100.00 |
| 8 | 2.2 | 997.8 | .22 | 99.78 |
| 16 | 18.5 | 979.3 | 1.85 | 97.93 |
| 20 | 9.2 | 970.1 | .92 | 97.01 |
| 30 | 81.8 | 888.3 | 8.18 | 88.83 |
| 40 | 250.4 | 637.9 | 25.04 | 63.79 |
| 60 | 508.8 | 129.1 | 50.88 | 12.91 |
| 74 | 60.7 | 68.4 | 6.07 | 6.84 |
| 100 | 57.4 | 11.0 | 5.74 | 1.10 |
| Pan | 11.0 | 0.0 | 1.10 | 0.00 |
| Total. | 1000.0 | 1000.0 | 100.00 | 100.00 |

VOIDS

| | |
|---|-------|
| Weight(gms.) 500 Cu. cm. sand. | 796.7 |
| Volume(Cu. Cm.) 100 gms. sand. | 62.8 |
| Volume(Cu. Cm.) water displaced by 100gms. sand | 37.4 |
| Voids in. Cu. Cm. | 25.4 |
| Percentage of Voids | 40.4 |

SPECIFIC GRAVITY

| | |
|--|-------|
| No. gms. sand used | 100.0 |
| Volume(Cu. Cm.) of water displaced by 100gms. sand | 37.4 |
| specific Gravity | 2.67 |

SAMPLE NO. 14.

Received from Decatur

Obtained at Decatur

TENSILE STRENGTH

| No. | 7 Day Test | 28 Day Test | 90 Day Test. |
|---------|------------|-------------|--------------|
| 1 | 205 | 340 | 505 |
| 2 | 232 | 315 | 509 |
| 3 | 185 | 365 | 510 |
| 4 | 225 | 302 | 508 |
| 5 | 202 | 350 | 530 |
| 6 | 214 | 320 | 501 |
| 7 | 219 | 340 | 511 |
| 8 | 208 | 336 | 546 |
| 9 | 214 | 246 | 493 |
| Average | 212. | 334 | 513 |

FINENESS

| Standard Mesh | Quantity Retained | Quantity Passing | Percent Retained | Percent Passing |
|---------------|-------------------|------------------|------------------|-----------------|
| 4 | 0.0 | 1000.0 | 0.00 | 100.00 |
| 8 | 259.9 | 740.1 | 25.99 | 74.01 |
| 16 | 373.8 | 366.3 | 37.38 | 36.63 |
| 20 | 27.3 | 339.0 | 2.73 | 33.90 |
| 30 | 93.7 | 245.3 | 9.37 | 24.53 |
| 40 | 115.8 | 129.5 | 11.58 | 12.95 |
| 60 | 91.5 | 38.0 | 9.15 | 3.80 |
| 74 | 15.3 | 22.7 | 1.53 | 2.27 |
| 100 | 11.2 | 11.5 | 1.12 | 1.15 |
| Pan | 11.5 | 0.0 | 1.15 | 0.00 |
| Total. | 1000.0 | 1000.0 | 100.00 | 100.00 |

VOIDS

SPECIFIC GRAVITY.

| | |
|---|-------|
| Weight (gms) 500 Cu. Cm. sand. | 832.7 |
| Volume (Cu. Cm.) 100. gms. sand. | 60.0 |
| Volume (Cu. Cm.) of water displaced by 100 gms. sand. | 38.1 |
| Voids in Cu. Cm. | 21.9 |
| Percentage of Voids. | 36.5 |

| | |
|---|-------|
| No. gms. sand used. | 100.0 |
| Volume (Cu. Cm.) of water displaced by 100 gms. sand. | 38.1 |
| Specific Gravity | 2.62 |

SAMPLE NO.15

Received from Freeport

Obtained at Freeport

TENSILE STRENGTH

| No. | 7 Day Test | 28 Day Test | 90 Day Test |
|---------|------------|-------------|-------------|
| 1 | 244 | 320 | 375 |
| 2 | 270 | 270 | 350 |
| 3 | 190 | 265 | 376 |
| 4 | 270 | 303 | 364 |
| 5 | 190 | 317 | 399 |
| 6 | 235 | 300 | 374 |
| 7 | 220 | 294 | 372 |
| 8 | 222 | 362 | 375 |
| 9 | 228 | 364 | 385 |
| Average | 230 | 311 | 375 |

FINENESS

| Standard Mesh | Quantity Retained | Quantity Passing | Percent Retained | Percent Passing |
|---------------|-------------------|------------------|------------------|-----------------|
| 4 | 0.0 | 1000.0 | 0.00 | 100.00 |
| 8 | 12.9 | 987.1 | 1.29 | 98.71 |
| 16 | 176.8 | 810.3 | 17.68 | 81.03 |
| 20 | 36.4 | 773.9 | 3.64 | 77.39 |
| 30 | 153.4 | 620.5 | 15.34 | 62.05 |
| 40 | 189.8 | 430.7 | 18.98 | 43.07 |
| 60 | 236.7 | 194.0 | 23.67 | 19.40 |
| 74 | 63.6 | 130.4 | 6.36 | 13.04 |
| 100 | 73.5 | 56.9 | 7.35 | 5.69 |
| Pan | 56.9 | 0.0 | 5.69 | 0.00 |
| Total | 1000.0 | 1000.0 | 100.00 | 100.00 |

VOIDS

| | |
|---|-------|
| Weight (gms.) 500 Cu. Cm. Sand. | 814.3 |
| Volume (Cu. Cm.) 100. gms. sand. | 61.4 |
| Volume (Cu. Cm.) of water displaced by 100 gms. sand. | 37.3 |
| Voids in Cu. Cm. | 24.1 |
| Percentage of Voids. | 39.2 |

SPECIFIC GRAVITY

| | |
|--|-------|
| No. gms. sand used | 100.0 |
| Volume (Cu. Cm.) of water displaced by 100 gms. sand | 37.3 |
| Specific Gravity | 2.68 |

SAMPLE NO. 16.

Received from Freeport Obtained at Freeport.

TENSILE STRENGTH

| No. | 7 Day Test | 28 Day Test | 90 Day Test |
|---------|------------|-------------|-------------|
| 1 | 140 | 152 | 292 |
| 2 | 130 | 174 | 274 |
| 3 | 175 | 184 | 290 |
| 4 | 136 | 162 | 232 |
| 5 | 170 | 185 | 278 |
| 6 | 140 | 220 | 260 |
| 7 | 172 | 200 | 248 |
| 8 | 150 | 187 | 266 |
| 9 | 155 | 150 | 256 |
| Average | 152 | 179 | 266 |

FINENESS

| Standard Mesh | Quantity Retained | Quantity Passing | Percent Retained | Percent Passing |
|---------------|-------------------|------------------|------------------|-----------------|
| 4 | 0.0 | 1000.0 | 0.00 | 100.00 |
| 8 | 17.2 | 982.8 | 1.72 | 98.28 |
| 16 | 118.6 | 864.2 | 11.86 | 86.42 |
| 20 | 34.6 | 829.6 | 3.46 | 82.96 |
| 30 | 197.8 | 631.8 | 19.78 | 63.18 |
| 40 | 322.9 | 308.9 | 32.29 | 30.89 |
| 60 | 267.1 | 41.8 | 26.71 | 4.18 |
| 74 | 27.6 | 14.2 | 2.76 | 1.42 |
| 100 | 12.6 | 1.6 | 1.26 | .16 |
| Pan | 1.6 | 0.0 | .16 | .00 |
| Total | 1000.0 | 1000.0 | 100.00 | 100.00 |

VOIDS

| | |
|---|-------|
| Weight (gms.) 500. Cu. Cm. Sand. | 791.2 |
| Volume (Cu. Cm.) 100 gms. sand. | 63.2 |
| Volume (Cu. Cm.) of water displaced by 100 gms. sand. | 35.8 |
| Voids in. Cu. Cm. | 27.4 |
| Percentage of Voids | 43.3 |

SPECIFIC GRAVITY.

| | |
|--|-------|
| No gms. sand used | 100.0 |
| Volume (Cu. Cm.) of water displaced by 100 gms. sand | 35.8 |
| Specific Gravity | 2.79 |

SAMPLE NO.17

Received from Aurora.

Obtained at Aurora.

TENSILE STRENGTH

| No. | 7 Day Test | 28 Day Test | 90 Day Test |
|---------|------------|-------------|-------------|
| 1 | 300 | 430 | 508 |
| 2 | 280 | 470 | 538 |
| 3 | 335 | 445 | 545 |
| 4 | 310 | 395 | 500 |
| 5 | 300 | 400 | 490 |
| 6 | 305 | 385 | 570 |
| 7 | 295 | 395 | 505 |
| 8 | 310 | 390 | 460 |
| 9 | 282 | 405 | 495 |
| Average | 302 | 413 | 512 |

FINENESS

| Standard Mesh | Quantity Retained | Quantity Passing | Percent Retained | Percent Passing |
|---------------|-------------------|------------------|------------------|-----------------|
| 4 | 0.0 | 1000.0 | 0.00 | 100.00 |
| 8 | 21.7 | 978.3 | 2.17 | 97.83 |
| 16 | 365.6 | 612.7 | 36.56 | 61.27 |
| 20 | 55.7 | 557.0 | 5.57 | 55.70 |
| 30 | 208.4 | 348.6 | 20.84 | 34.86 |
| 40 | 228.2 | 120.4 | 22.82 | 12.04 |
| 60 | 108.5 | 11.9 | 10.85 | 1.19 |
| 74 | 5.1 | 6.8 | .51 | .68 |
| 100 | 2.2 | 4.6 | .22 | .46 |
| Pan | 4.6 | 0.0 | .46 | .00 |
| Total | 1000.0 | 1000.0 | 100.00 | 100.00 |

VOIDS

| | |
|--|-------|
| Weight (gms.) 500 Cu. Cm. Sand. | 833.4 |
| Volume (Cu. Cm.) 100 gms. sand. | 60.0 |
| Volume (Cu. Cm.) of water displaced by 100 gms. sand | 37.4 |
| Voids in Cu. Cm. | 22.6 |
| Percentage of Voids | 37.7 |

SPECIFIC GRAVITY.

| | |
|--|-------|
| No. gms sand used | 100.0 |
| Volume (Cu. Cm.) of water displaced by 100 gms. sand | 37.4 |
| Specific Gravity | 2.67 |

SAMPLE NO.18

Received from Joliet

Obtained at Joliet.

TENSILE STRENGTH

| No. | 7 Day Test | 28 Day Test | 90 Day Test |
|---------|------------|-------------|-------------|
| 1 | 99 | 150 | 170 |
| 2 | 70 | 145 | 185 |
| 3 | 95 | 140 | 188 |
| 4 | 88 | 170 | 150 |
| 5 | 85 | 140 | 145 |
| 6 | 95 | 140 | 235 |
| 7 | 88 | 150 | 210 |
| 8 | 96 | 145 | 192 |
| 9 | 75 | 120 | 200 |
| Average | 89 | 144 | 186. |

FINENESS

| Standard Mesh | Quantity Retained | Quantity Passing | Percent Retained | Percent Passing |
|---------------|-------------------|------------------|------------------|-----------------|
| 4 | 0.0 | 1000.0 | 0.00 | 100.00 |
| 8 | 5.0 | 995.0 | .50 | 99.50 |
| 16 | 51.2 | 943.8 | 5.12 | 94.38 |
| 20 | 32.9 | 910.9 | 3.29 | 91.09 |
| 30 | 39.99 | 511.0 | 39.99 | 51.10 |
| 40 | 353.0 | 158.0 | 35.30 | 15.80 |
| 60 | 106.4 | 51.6 | 10.64 | 5.16 |
| 74 | 10.2 | 41.4 | 1.02 | 4.14 |
| 100 | 7.6 | 53.8 | .76 | 5.38 |
| Pan | 33.8 | 0.0 | 3.38 | 0.00 |
| Total. | 1000.0 | 1000.0 | 100.00 | 100.00 |

VOIDS

| | |
|--|-------|
| Weight (gms.) 500. Cu. Cm. sand. | 714.8 |
| Volume (Cu. Cm.) 100. gms sand | 69.9 |
| Volume (Cu. Cm.) of water displaced by 100 gms. sand | 38.4 |
| Voids in Cu. Cm. | 31.5 |
| Percentage of Voids | 45.0 |

SPECIFIC GRAVITY

| | |
|---|-------|
| No. gms sand used. | 100.0 |
| Volume (Cu. Cm.) of water displaced by 100 gms. sand. | 38.4 |
| Specific Gravity | 2.61 |

SAMPLE NO. 19

Received from. Moline

Obtained at Moline.

TENSILE STRENGTH

| No | 7 Day Test | 28 Day Test | 90 Day Test |
|---------|------------|-------------|-------------|
| 1 | 170 | 220 | 245 |
| 2 | 145 | 220 | 243 |
| 3 | 190 | 260 | 201 |
| 4 | 195 | 265 | 240 |
| 5 | 180 | 268 | 283 |
| 6 | 160 | 255 | 237 |
| 7 | 190 | 250 | 258 |
| 8 | 160 | 228 | 232 |
| 9 | 175 | 268 | 244 |
| Average | 174 | 248 | 242. |

FINENESS

| Standard Mesh | Quantity Retained | Quantity Passing | Percent Retained | Percent Passing |
|---------------|-------------------|------------------|------------------|-----------------|
| 4 | 0.0 | 1000.0 | 0.00 | 100.00 |
| 8 | 23.0 | 997.0 | 2.30 | 99.70 |
| 16 | 119.2 | 857.8 | 11.92 | 85.78 |
| 20 | 23.1 | 824.7 | 2.31 | 82.47 |
| 30 | 208.9 | 615.8 | 20.89 | 61.58 |
| 40 | 355.8 | 260.0 | 35.58 | 26.00 |
| 60 | 229.5 | 30.5 | 22.95 | 3.05 |
| 74 | 20.4 | 10.1 | 2.04 | 1.01 |
| 100 | 8.5 | 1.6 | .85 | .16 |
| Pan | 1.6 | 0.0 | .16 | .00 |
| Total | 1000.0 | 1000.0 | 100.00 | 100.00 |

VOIDS

SPECIFIC GRAVITY

| | |
|--|-------|
| Weight (gms.) 500. Cu. Cm. sand | 846.0 |
| Volume (Cu. Cm.) 100 gms sand. | 59.1 |
| Volume (Cu. Cm.) of water displaced by 100 gms. sand | 38.5 |
| Voids in Cu. Cm. | 20.6 |
| Percentage of Voids | 34.8 |

| | |
|---|-------|
| No gms sand used | 100.0 |
| Volume (Cu. Cm.) of water displaced by 100 gms. sand. | 38.5 |
| Specific Gravity | 2.60 |

7

SAMPLE NO.20.

Received from Urbana

Obtained at Urbana

TENSILE STRENGTH

| No. | 7 Day Test | 28 Day Test | 90 Day Test |
|---------|------------|-------------|-------------|
| 1 | 220 | 335 | 422 |
| 2 | 250 | 275 | 408 |
| 3 | 278 | 265 | 440 |
| 4 | 262 | 350 | 415 |
| 5 | 330 | 298 | 335 |
| 6 | 315 | 318 | 380 |
| 7 | 275 | 295 | 470 |
| 8 | 240 | 310 | 386 |
| 9 | 264 | 300 | 415 |
| Average | 266 | 305 | 417 |

FINENESS

| Standard Mesh | Quantity Retained | Quantity Passing | Percent Retained | Percent Passing |
|---------------|-------------------|------------------|------------------|-----------------|
| 4 | 0.0 | 1000.0 | 0.00 | 100.00 |
| 8 | 276.0 | 724.0 | 27.60 | 72.40 |
| 16 | 408.1 | 315.9 | 40.81 | 31.59 |
| 20 | 49.3 | 266.6 | 4.93 | 26.66 |
| 30 | 76.3 | 190.3 | 7.63 | 19.03 |
| 40 | 29.9 | 160.4 | 2.99 | 16.04 |
| 60 | 92.3 | 68.1 | 9.23 | 6.81 |
| 74 | 12.6 | 55.5 | 1.26 | 5.55 |
| 100 | 10.6 | 44.9 | 1.06 | 4.49 |
| Pan | 44.9 | 0.0 | 4.49 | 0.00 |
| Total. | 1000.0 | 1000.0 | 100.00 | 100.00 |

VOIDS

| | |
|--|-------|
| Weight (gms.) 500 Cu. Cm. sand. | 796.7 |
| Volume (Cu. Cm.) 100 gms sand | 62.7 |
| Volume (Cu. Cm.) of water displaced by 100 gms. sand | 37.4 |
| Voids in Cu. Cm. | 25.3 |
| Percentage of Voids | 40.3 |

SPECIFIC GRAVITY

| | |
|--|-------|
| No. gms. sand used | 100.0 |
| Volume (Cu. Cm.) of water displaced by 100 gms. sand | 37.4 |
| Specific Gravity | 2.67 |

TABLE.5

RANKING OF SANDS

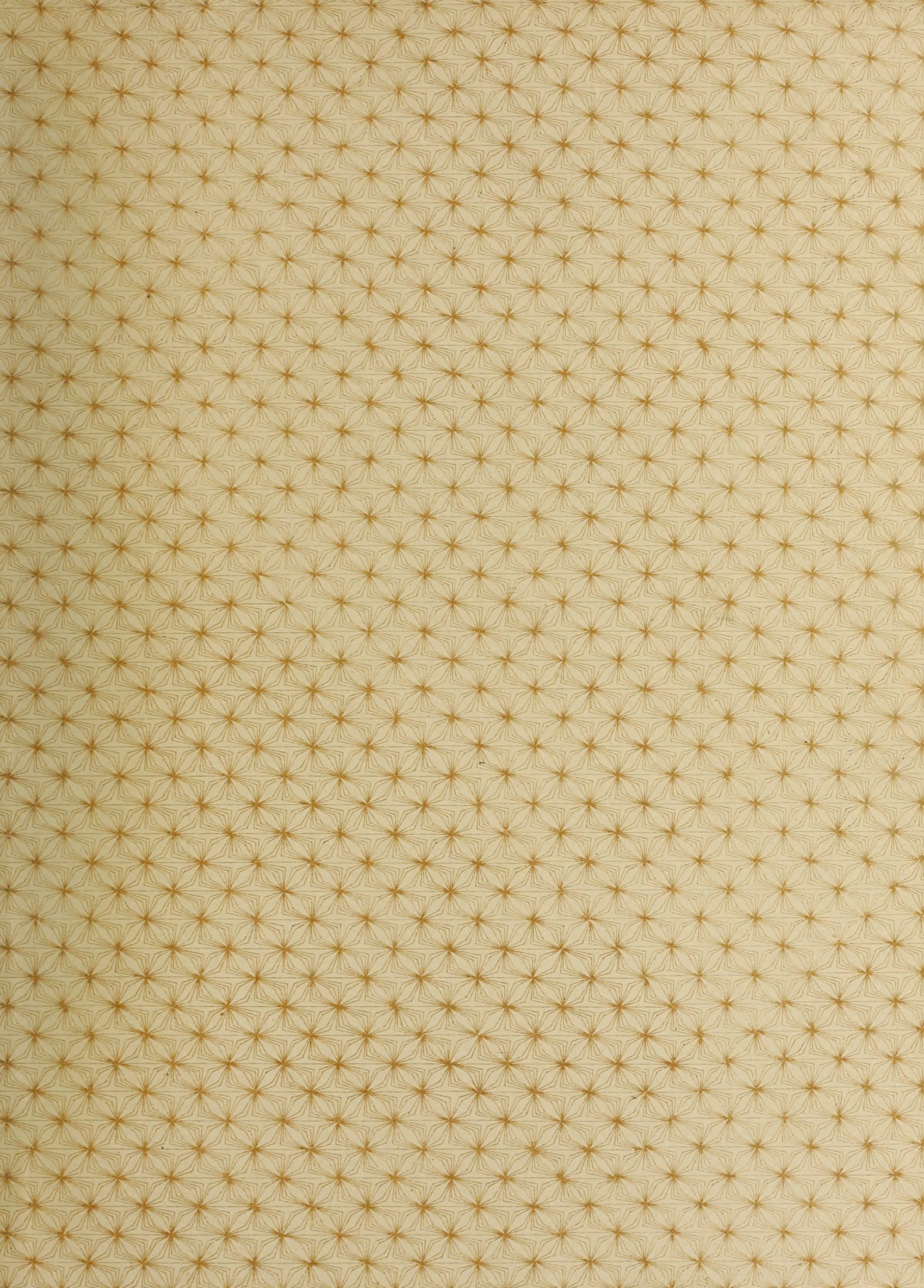
TENSILE STRENGTH

VOIDS

| Sample Number | Sand Received from | Tensile Strength |
|---------------|--------------------|------------------|
| 12 | Champaign | 454 |
| 17 | Aurora | 413 |
| 6 | Elgin | 381 |
| 5 | Elgin | 377 |
| 4 | Chicago | 355 |
| 14 | Decatur | 334 |
| 15 | Freeport | 311 |
| 20 | Urbana | 305 |
| 2 | Chicago | 269 |
| 8 | Rockford | 266 |
| 3 | Chicago | 264 |
| 10 | Springfield | 258 |
| 11 | Springfield | 253 |
| 9 | Springfield | 252 |
| 19 | Moline | 248 |
| 7 | Bloomington | 236 |
| 13 | Galesburg | 217 |
| 1 | Chicago | 186 |
| 16 | Freeport | 179 |
| 18 | Joliet | 144 |

| Sample Number | Sand Received from | Percent Voids |
|---------------|--------------------|---------------|
| 18 | Joliet | 45.0 |
| 4 | Chicago | 43.3 |
| 16 | Freeport | 43.3 |
| 1 | Chicago | 42.4 |
| 13 | Galesburg | 40.4 |
| 20 | Urbana | 40.3 |
| 15 | Freeport | 39.2 |
| 7 | Bloomington | 38.9 |
| 2 | Chicago | 38.4 |
| 17 | Aurora | 37.7 |
| 6 | Elgin | 37.5 |
| 8 | Rockford | 36.9 |
| 10 | Springfield | 36.7 |
| 12 | Champaign | 36.7 |
| 14 | Decatur | 36.5 |
| 9 | Springfield | 35.9 |
| 11 | Springfield | 34.9 |
| 3 | Chicago | 34.8 |
| 19 | Moline | 34.8 |
| 5 | Elgin | 33.8 |





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